

Before the  
**Federal Communications Commission**  
Washington DC 20554

In the Matter of )  
 )  
Promoting Spectrum Access for Wireless )  
Microphone Operations )  
 )  
Expanding the Economic and Innovative )  
Opportunities of Spectrum Through Incentive )  
Auctions )

Docket No. 14-166

Docket No. 12-268

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Federal Communications Commission  
Office of the Secretary

**COMMENTS OF SENNHEISER ELECTRONIC CORPORATION**

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## SUMMARY

Professional news and entertainment productions often times require all locally vacant UHF channels to operate wireless microphones (monitors and intercom links are included within this definition), occasionally numbering more than one hundred. Some major productions, such as the Super Bowl, the Grammy Awards, and the Democratic/Republican conventions, use hundreds of wireless systems, requiring even more spectrum, including, through use of Special Temporary Authorizations, spectrum bands considered in this proceeding. Sennheiser welcomes new spectrum opportunities suggested here by the Commission.

One of the most important goals of this proceeding must be to find a suitable replacement for lost UHF spectrum as well as spectrum to meet the growing demand for wireless microphones. Sennheiser supports moving less critical microphone applications out of UHF. Nevertheless, clean blocks of UHF that are highly reliable (ones not shared with white space device or limited by out-of-band emissions from adjacent services) are required for hyper-critical wireless microphone applications (those demanding the highest audio quality and where a second "take" is not an option).

The Commission acknowledges both the importance of wireless microphones to our economy and society, as well as the difficulty the industry now faces given the loss of UHF spectrum and the transition from 600 MHz, especially in light of the loss of 700 MHz spectrum in 2010. The past 700 MHz and future 600 MHz reallocation processes have caused and will cause further confusion to many operators and entities, despite the best efforts of manufacturers to educate end users. Additional changes to the regulatory environment, specifically new technical rules, will exacerbate the situation and threaten to stymie the economic health of the industry and its contributions to content creation.

The FCC should develop a regulatory scheme with simplicity and flexibility in mind.

Sennheiser suggests the Commission classify wireless microphone users into three categories: 1) licensed professional "Class A" (Part 74 eligible users), which require reserve and priority access to channels, access to large amounts of spectrum (up to 350 MHz for large, important national events), and at times higher power transmitters (*e.g.* 250 mW on UHF channels, 1W in other bands); 2) unlicensed "Class B" users, which include professional users with less-exacting needs, such as regional and community theater groups, and civic applications, use fewer than fifty microphones per event, and can adequately operate with lower (up to 50 mW) transmitter power; and 3) unlicensed "Class C" hobbyist users, which require a minimal number of microphones and can operate on unlicensed ISM bands.

Additionally, in considering the issues raised in this proceeding, the Commission should look at wireless microphone performance requirements and consider spectrum efficiencies in light of current and foreseeable technology. To be clear, wireless microphone technology is not inefficient, even though many products are analog. Sennheiser designs the most advanced wireless microphone products in the world, both analog and digital, in order to best serve its customers. But the unique needs of wireless microphones limit the gains in efficiencies found in other digital products that do not have the specification demands of wireless microphones.

The Commission's rules should continue to reflect the high standards necessary for professional performance, which include negligible latency, and the proven benefits that wireless microphones provide to the American economy.



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**COMMENTS OF SENNHEISER ELECTRONIC CORPORATION**

Sennheiser Electronic Corporation ("Sennheiser") hereby comments on the Federal Communications Commission's ("FCC" or "Commission") Notice of Proposed Rulemaking ("NPRM") in the above-captioned proceeding.<sup>1</sup>

Sennheiser appreciates the Commission's efforts to work to ensure that wireless microphones secure adequate and appropriate spectrum. While Sennheiser holds steadfast in its view that certain wireless microphone uses require reliable and interference-free UHF frequencies, as a manufacturer at the forefront of innovative wireless microphone technology, it supports opening other spectrum bands for both critical and non-critical wireless microphone use.

**BACKGROUND**

Sennheiser Electronic GmbH & Co. KG, headquartered in Germany, is a global leader in advanced microphone technology, RF-wireless and infrared sound transmission, headphone

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<sup>1</sup> *In the Matter of Promoting Spectrum Access for Wireless Microphone Operations; Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Notice of Proposed Rulemaking, Docket Nos. 14-166 and 12-268 (rel. Sept. 30, 2014) ("NPRM").

transducer technology, and active noise cancellation. Sennheiser Electronic Corporation is the main U.S. sales and marketing entity, located in Old Lyme, Connecticut. Sennheiser also operates a research center in San Francisco, California, and a manufacturing plant in Albuquerque, New Mexico that produces the majority of Sennheiser wireless microphones sold in North America, South America, Canada, and Asia.

Wireless microphones are more than a convenience. They are vital to a major component of the U.S. economy – essential to the entertainment and news industries – and support one of the United States' major export sectors, *i.e.* the film industry. Wireless microphones are ubiquitous in all aspects of the entertainment business, in news reporting, in sports, and in U.S. commercial, civic, and religious life. They are essential to the production of virtually all non-studio broadcast events, and to nearly all studio-produced programs as well. These include team sports from local college broadcasts to the Super Bowl, the World Series, the Final Four, and the Stanley Cup; the Democratic and Republican political conventions; post-election national and local coverage; the Oscar, Emmy, and Grammy Awards shows; events such as the Olympics, NASCAR races, the Kentucky Derby, and major golf and tennis tournaments; and on-the-scene news reporting of all kinds, both local and national. These broadcasts routinely attract millions of viewers, and often use more than 100 wireless microphones, which requires all available UHF channels between 470 – 698 MHz (not including channel 37). Major events such as the Super Bowl, the Video Music Awards, and the Country Music Award Fanfare Festival operate up to 1000 wireless microphones, which requires 350 MHz of spectrum, much of it obtained through special temporary authorizations.

Motion-picture production, from Hollywood blockbusters with nine-digit budgets to student work at the local community college, relies heavily on wireless microphones for clear,

accurate audio. Live events, from Broadway productions to stadium-sized outdoor concerts, need wireless microphones to reach the back row as well as provide input to ADA compliant hearing assist systems. Presenters in auditoriums, lecture halls, and houses of worship find them indispensable.

The U.S. public expects the very highest standards of production quality in all these forms of television, radio, film, and live entertainment. As a practical matter, this means “CD” sound quality rather than MP3, with no discernable latency (sound lag), for entertainment, news and sophisticated sound productions at concerts and Broadway productions.

The wireless microphone industry – manufacturers, owners, and users – have faced significant changes in recent years that have made the regulatory environment much more complex and difficult. In 2010, the Commission required that wireless microphones transition off the 698-806 MHz band, eliminating more than a third of available UHF spectrum.<sup>2</sup> The industry now must prepare for its second move off previously-available spectrum in a few years.

## DISCUSSION

The Commission’s aim in considering solutions to the issues raised here must be simplicity. To this end, Sennheiser proposes a framework of user group categories that will aid in determining what wireless microphone uses are appropriate in what spectrum bands. As well, Sennheiser explains the nature and capabilities of wireless microphone technology. Taken

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<sup>2</sup> *Revisions to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band, WT Docket No. 08-166, Public Interest Spectrum Coalition, Petition for Rulemaking Regarding Low Power Auxiliary Stations, Including Wireless Microphones, and the Digital Television Transition, WT Docket No. 08-167, Amendment of Parts 15, 74 and 90 of the Commission’s Rules Regarding Low Power Auxiliary Stations, Including Wireless Microphones, Report and Order and Further Notice of Proposed Rulemaking, 25 FCC Rcd 643, ¶ 87 (2010) (“2010 Wireless Microphone Order”).*



together, these two factors serve to guide the Commission in creating new opportunities for wireless microphone use.

**A. Wireless Microphone User Groups and Demand.**

The Commission seeks information on the current state of wireless microphone use.<sup>3</sup> The Commission identifies two general types of wireless microphone user groups: licensed professional and unlicensed amateur.<sup>4</sup> Sennheiser believes that it is more useful to consider three classes of wireless microphone user groups.

The Class A user group would be licensed, professional users, specifically those eligible for Part 74 licensing.<sup>5</sup> Class A uses include: TV broadcast, film production, news gathering, professional concert, theater, and historic political events. This group has the most demanding performance requirements, requiring extremely high fidelity and low latency links for critical on-air/on-stage wireless microphones and ear monitors to allow for a full audio response and dynamic range. Given the high standards required by performers and news media, and the expectations of audiences, for critical on-air/stage use, it is particularly important for Class A users to have access to clean blocks of UHF spectrum for hyper-critical applications that require high levels of reliability and the favorable propagation characteristics of UHF frequencies. Class A users also often require priority access to channels shared with unlicensed devices. At times, Class A users employ higher power transmitters of up to 250 mW in the UHF band (up to 1W in other bands) for uses requiring longer ranges, such as broadcast coverage of large stadium games or golf tournaments.

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<sup>3</sup> See generally NPRM at ¶¶ 32-49.

<sup>4</sup> NPRM at ¶¶ 33-37.

<sup>5</sup> 47 C.F.R. ¶ Part 74.



Class B users are civic groups and other productive users of wireless microphones – regional and community theaters, churches and religious organizations not engaged in broadcast activities, schools, corporations, trade show and hotel conference centers, regional performance touring acts, and other users. This group requires the use of fewer microphones and channels than Class A users, and can operate adequately at 50 mW. There are times when Class B users stage professional level productions. For this reason, while Class B users do not routinely use fifty or more microphones, which would make them eligible for a Part 74 license, they often require use of a large number of microphones and better reliability than the products operating in the license-free ISM bands. These “mid-level” users will be severely affected by many of the Commission’s proposed changes.

To highlight a gap in the current regulatory scheme, while recent changes to the Part 74 rules now allow large venue owners and operators as well as professional sound companies to operate as licensed users, there are some Class B professional users that do not fall into these categories and thus cannot take advantage of the interference protections afforded Part 74 licensees. Non-profit theater groups are a prime example: Many operate with around thirty microphones, requiring thoughtful coordination and frequencies with better propagation, higher reliability and greater channel count than ISM bands offer. Yet these users do not qualify to be Part 74 licensees and must operate with an unlicensed status. These users need to obtain interference protection for their performances, something that will become more necessary as available UHF spectrum decreases and portable white space devices enter the market.<sup>6</sup>

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<sup>6</sup> Sennheiser addresses some of these issues in its comments filed concurrently in the Part 15 NPRM proceeding.

Therefore, a path for them to register for interference protection from white space devices should remain.<sup>7</sup>

Finally, Class C users are hobbyist users, such as garage music groups, karaoke bars and small assemblies. Use of unlicensed ISM bands is sufficient for Class C use. Over the past few years, manufacturers have introduced more microphone systems for unlicensed bands, transitioning many amateur users out of the UHF band.

The Commission seeks comment on the current and future demand for wireless microphone use.<sup>8</sup> Wireless microphone use in the United States is growing. The number of events covered by ESPN that required wireless microphones doubled between 2010 and 2014. There is rising demand for high-tech shows on Broadway, which just announced twenty new shows for 2015, many with touring versions to follow in theaters throughout the U.S. As well, content creation is a major – \$1 trillion – growing industry in the U.S.<sup>9</sup> In 2013, the most robust job growth was in the entertainment business.<sup>10</sup> The number of new content providers, including former service providers such as Amazon and Netflix, is growing. American core-copyright products have a three to one export to import ratio, the highest of any U.S. product or service.<sup>11</sup> Historical speeches and events must be recorded in high quality audio, to assure access a hundred years from now and to support future high resolution media formats. These factors all drive the

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<sup>7</sup> Sennheiser addresses this in the Part 15 proceeding, where the Commission has proposed eliminating registration protection for unlicensed wireless microphones.

<sup>8</sup> NPRM at ¶ 38.

<sup>9</sup> Sennheiser detailed these facts in its comments in the incentive auction proceeding. *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Comments of Sennheiser Electronic Corporation, Docket No. 12-268 at 4 (filed Nov. 4, 2013).

<sup>10</sup> *Id.*

<sup>11</sup> *Id.*

need and importance of spectrum required for content creation.

**B. Wireless Microphones Are at The Forefront of Technical Innovation.**

The Commission seeks information on the development and manufacturing of wireless microphone devices, and the efficiency of the technologies.<sup>12</sup>

Wireless microphones have excelled at spectrum sharing and frequency reuse, efficiently sharing TV bands for decades with TV broadcast, land mobile communications, and other microphones. They are used extremely efficiently in locations where demand is high, such as in the Times Square theater district where nearly seventeen hundred microphones operate every night during Broadway performances. The NASDQ, MTV and ABC Studios also use multiple microphones in the same location. This is very densely packed spectrum. Other highly efficient uses occur in theme parks such as Disney World, on the Las Vegas Strip, and at major TV networks such as NBC Studios at 30 Rockefeller Center where 700 wireless microphones are in use.

Customer demand for sophisticated wireless audio products, coupled with the ever-present need to use spectrum on a secondary basis and healthy competition in the marketplace, has continually pushed innovation. Over the years, productions have become increasingly sophisticated, demanding a greater number of microphones with higher fidelity. This trend is not declining, or even flattening, it is accelerating.

Manufacturers have markedly increased the useable density of microphones per channel over the past several years. The Digital 9000 system, the SK 5212-II, and SKM 5200-II are examples of equipment that Sennheiser has introduced within the past five years that allow denser packing of microphones in an available channel, without compromise to audio quality and

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<sup>12</sup> See generally NPRM at ¶¶ 32-49



RF transmission reliability. The wireless microphone industry always has moved forward with technological advances on its own, without intervention from regulators, because it is what the market has demanded. Given these healthy industry dynamics, regulation should be done with a very light touch.

The NPRM seeks information regarding innovation and efficiency, and in so doing implies that analog wireless microphone devices are less efficient than digital.<sup>13</sup> Sennheiser has shown this is not the case.<sup>14</sup> Sennheiser is no stranger to digital modulation, having introduced its first digital microphone system in 2001. However, uncompressed digital modulation is not inherently more spectrum-efficient than analog modulation. Using digital technology to achieve major gains in spectrum efficiency requires compression, which in turn adds to latency, reduces audio quality, or both. While these compromises are tolerable in other technologies such as cellular phones, wireless microphones must transmit in real-time with nearly negligible latency.

In general, significant gains in spectral efficiency from the use of digital devices are possible for applications not requiring high fidelity and negligible latency, for instance voice transmissions on backstage intercoms, but not for professional performances, historical speeches, or music recordings. Wireless microphones for professional use must satisfy three technically demanding criteria: very high audio fidelity, near-absolute reliability and extremely low latency. The importance of fidelity and reliability are self-evident. The latency requirement arises because a performer on stage or in the studio is exposed to his own voice, via monitor speakers or in-ear monitors, through the same microphone system that delivers his voice to the audience. Any significant delay becomes intolerable to the performer and deteriorates the experience for

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<sup>13</sup> NPRM at ¶ 52.

<sup>14</sup> See Comment of Sennheiser Electronic Corporation, Docket No. 12-268 at 6 (filed Jan. 25, 2013) (explaining the spectrum efficiency of an analog transmission on a 200 kHz channel).



the audience (akin to viewing a poorly-dubbed Godzilla movie). The practical upper limit on latency for an audio system is less than ten thousandths of a second through the entire system, from the microphone transducer back to the ear monitor.<sup>15</sup> Some sound engineers and artists are very sensitive to latency and request an even lower “upper limit.” Backstage operations, such as intercom, cueing, and interruptible fold-back, as well as non-professional equipment, such as wireless microphone systems used by schools, can tolerate slightly more latency; these uses are more appropriate for highly compressed digital operations, and are where gains in spectrum efficiency can be achieved.

Clean spectrum with a low noise floor is a prerequisite to maximize spectral efficiency, especially with digital systems which use all or nothing “cliff effect” transmissions. In a channel with a low noise floor, compression can be used to densely pack many microphones into the channel. In a channel with a higher noise floor, compression must be used instead to increase the carrier to noise ratio to ensure the robustness of the transmission. For this reason, high efficiency should not be expected in spectrum with high noise floors, such as the 600 MHz duplex gap and VHF channels, as compared to the current reserved microphone channels in the UHF band.

The Commission asks about uses where analog devices are necessary or appropriate, for what types of operations digital devices are well-suited, and what technological changes may enable more digital wireless microphone applications.<sup>16</sup> The criteria imposed on professional wireless microphones are demanding: extremely high audio quality, inaudible background noise, adequate range, effective penetration of bodies and building materials, long battery life, no drop-outs, low latency, compact size of components worn or held by the talent, and reasonable cost.

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<sup>15</sup> See Comment of Sennheiser Electronic Corporation, Docket No. 12-268, at 6 (filed Jan. 25, 2013).

<sup>16</sup> NPRM at ¶ 56.

Any combination of a few of these attributes can be optimized but only at the compromise of one or more of the remaining ones. Sennheiser's Digital 9000 series is a prime example. It represents the state of the art in wireless microphone design and is the "benchmark of the industry." This is the best sounding, most reliable and most spectrally efficient system Sennheiser has ever produced, and most customers who can afford it, choose it. However, the body pack transmitter is bigger than the high end analog SK 5212-II transmitter. Many Broadway shows or Hollywood studios find it necessary to choose a system with a miniature analog body pack transmitter, which may be hidden under clothing, in hair, or elsewhere out of sight. These users must continue to have access to such transmitters.

With regard to whether the Commission should promote technological advances in wireless microphone radio technologies, Sennheiser believes that the Commission should allow the market to dictate what technology is used. Many features suggested in the NPRM, such as modular products with wide-frequency agility, have been available from Sennheiser for more than twenty years, with multiple generations of improvements in spectral efficiency and clear frequency sensing capability. These offerings evolved due to market demand. However, many factors, such as the needs of a particular venue, use requirements, and price constraints, inform what technology is best suited for a particular user or user group. Manufacturers must be allowed to provide technology for all users.

The Commission seeks comment on the state of analog and digital wireless microphone technologies that operate on the TV bands.<sup>17</sup> Sennheiser has previously explained that manufacturers have been moving non-critical uses off these bands. However, the news and entertainment industries still require UHF frequencies for critical uses. More digital products

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<sup>17</sup> NPRM at ¶ 54.

have been introduced in recent years. This trend will continue. However, some customers still choose analog devices, not because of the modulation technique, but for other reasons, such as a sub-miniature body pack transmitter or extremely low latency. Over time, higher-performance, small, digital components are likely to become available to close these gaps. In the meantime, customers should continue to be able to choose products that meet their exacting needs.

The Commission seeks comment on the usefulness of ETSI masks in promoting spectral efficiency.<sup>18</sup> In Sennheiser's view, this is a good example of how the wireless microphone industry is technologically progressive, as all Sennheiser devices have met these masks for decades. Complex stage productions require large numbers, routinely greater than fifty microphones working in close proximity to each other, and designing equipment that exceeds the standards of these ETSI masks is the best way to accomplish this. Therefore, Sennheiser supports adoption of these masks.

Sennheiser vigorously objects to the suggestion that allegedly "inefficient" wireless microphone technologies must be "phased out."<sup>19</sup> While the transition to digital modulation has allowed for gain of spectral efficiencies with other technologies, such as mobile radio where the Commission has successfully transitioned users to narrowband technology to achieve efficiency gains, this is not the same situation. In those cases, digitalization allowed for compression. Here, as discussed above, due to fidelity and latency concerns, the same type of compression cannot be applied to wireless microphones, except for those with the absolute lowest performance requirements.

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<sup>18</sup> NPRM at ¶ 57.

<sup>19</sup> See NPRM at ¶ 59.



The Commission seeks comment on the application of general purpose wireless standards to wireless microphone technologies.<sup>20</sup> This idea, too, is inapplicable to the wireless microphone industry, given the unique performance requirements and radio frequency design of the products. Wireless microphones achieve spectrum sharing through low power and prior coordination. While uniform standards have promoted technological gains and spectrum efficiency for certain industries such as Wi-Fi, those standards are industry-designed, not dictated by a regulatory authority. The Commission's role is to be technologically neutral, not to specify standards for the purpose of improving performance or reducing costs.

With regard to modularity,<sup>21</sup> as with other design choices, there are tradeoffs and concerns. Sennheiser has offered modularity in its products since 1978. Products include multi-channel modular receiver racks, transmitters with removable microphone elements and battery sleds, and tuner modules that can be swapped. However, modularity significantly increases cost, making it outside the budget for a large portion of users.

The Commission also seeks information regarding the tunability of equipment within a band and of multi-band equipment, including the tradeoffs and considerations of designing such equipment.<sup>22</sup> Sennheiser makes tunable equipment. The degree of tunability, the filtering of potentially interfering signals, and the linearity of components are mutually related and generally determine the equipment's capability for multi-channel (multi-microphone) operation. Optimizing multiple properties significantly increases the cost. The Sennheiser Digital 9000 receiver tunes throughout the entire available UHF range and provides high spectral efficiency (dense packing of microphones into slivers of spectrum), but costs approximately \$10,000 per

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<sup>20</sup> NPRM at ¶ 60.

<sup>21</sup> NPRM at ¶ 62.

<sup>22</sup> NPRM at ¶¶ 63 and 64.



microphone, a cost outside the reach of most users. Less expensive models have a narrower tuning range, different filtering, lower linearity, or a combination of these parameters. Multi-band equipment has not been practical due to antenna system requirements, filtering requirements, size constraints, and associated costs.

The Commission also seeks comment on whether wireless microphones would benefit from access to a database.<sup>23</sup> Wireless microphone technologies do rely upon databases – wireless microphones use sensing and/or manual database checks to find clear frequencies to ensure clean transmissions. Professional and most semi-professional wireless microphones have a scan function that is designed to sense (“look”) for open channels and frequencies and select which ones to use. Manufacturers have offered databases on their websites for years (and charts before the existence of websites) to allow users to locate clear channels. Given the need to operate on clear, clean channels, this has served as a successful approach to interference management: Because it is the engineer’s job to ensure their wireless microphones operate continuously through the production without drop-outs, they cannot choose to operate on the same frequencies as other users. The absence of complaints indicates that the current system works.

Adding a database control requirement would unnecessarily increase cost and complexity to wireless microphones. Moreover, it would increase operating complexity. And, requiring database control would impose a cumbersome regulatory burden on wireless microphone users, who would need to register and likely pay fees.<sup>24</sup> Moreover, unlicensed and licensed

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<sup>23</sup> NPRM at ¶ 65.

<sup>24</sup> In particular, Sennheiser believes this database requirement would create a difficult situation for Class B users, such as non-profit theaters, schools and houses of worship, that would face financial challenges if required to pay registration and use fees, yet will not be adequately served by ISM devices, which provide fewer channels and less reliability.

microphones have coexisted on the same spectrum for years without a required database; Sennheiser questions why a requirement is now necessary. For these reasons, Sennheiser objects to any database requirement.

The Commission seeks comment on the possible use of electronic keys, dynamic power variability, and other technologies intended to limit interference. The stellar record of peaceful coexistence of wireless microphones with the primary services that they have shared in other bands should indicate that an electronic key is unnecessary. Should the Commission be concerned about incumbents that may be particularly sensitive to sharing with wireless microphones, the most sensible and expedient solution would be to restrict use of certain bands to Class A licensed wireless microphones operators. Any additional technology requirements will add cost and complexity to equipment and system operations.

In terms of power variability, Sennheiser has developed a wireless microphone with dynamic power variability for the 1.9 GHz band. This product is appropriate for that band and for Class B semi-professional use. Class A users should not be subject to a dynamic power variability requirement, as they must be able to manually control power. Thus, while this technology may be useful in some situations, it should not be mandated.

Finally, the Commission should be cognizant that flexibility in technical specifications may promote further innovation in wireless microphone systems. The Commission adopted flexible-use service and technical rules for both 600 MHz and 700 MHz wireless licensees, in part for the purpose of speeding deployment.<sup>25</sup> In the same vein, the Commission should consider flexible-use rules for wireless microphones. This will allow the industry to move forward, even in light of the difficulties discussed herein.

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<sup>25</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, at ¶5 (rel. June 2, 2014).

**C. Operations on the TV Bands.**

**1. The Transition of Wireless Microphones.**

The Commission additionally seeks comment on general issues effecting the transition of wireless microphones as a result of the incentive auction.<sup>26</sup>

Commission proceedings have resulted in two spectrum transitions for wireless microphones, first from the 700 MHz band and now from the 600 MHz band. An extensive installed base of well more than one million wireless microphone systems in total was or will be made unusable due to these regulatory changes. Owners face significant economic costs as well as premature disruption to the use of technology.<sup>27</sup> As well, there are proposed modifications to the operation of wireless microphones in the 600 MHz guard bands and duplex gap and with regard to what TV remains after the incentive auction. As the Commission notes, “the precise amount of TV bands spectrum that will be repurposed will be known only following the auction,” anticipating that many wireless microphone users will need to move operations out of the TV bands no later than 39 months after the Commission issues a PN reassigning TV channels (and manufacturers will need to stop selling microphones tunable to these frequencies within 18 months).

Beyond the general havoc involved with transitioning off spectrum, the new regulatory regime creates many additional uncertainties. The elimination of the reserve UHF microphone channels for wireless microphone use, and proposed white space device access to channels 14-20 (which Sennheiser opposes), will eliminate clean, “safe haven” channels for wireless

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<sup>26</sup> NPRM at ¶¶ 44-48.

<sup>27</sup> On behalf of these effected owners/users, Sennheiser requested the Commission reconsider its decision not to establish a reimbursement scheme for replacement wireless microphones. *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Petition for Reconsideration of Sennheiser Electronic Corporation, Docket No. 12-268 (filed Sept. 15, 2014).



microphones. Television stations currently operating in the 600 MHz band that choose to remain on the air will be moved to lower channels, congesting the remaining portion of the TV band available to wireless microphones. The 39 month post-Public Notice transition period for use of the repurposed 600 MHz band is less than certain, given that many wireless licensees have expressed interest in testing and beginning operations as soon as possible. The guard bands will vary among markets. And, if the Commission adopts its proposal to ban wireless microphones that can tune to repurposed spectrum, something Sennheiser opposes in the Part 15 proceeding, a wireless microphone will be lawful in some cities but not in others. Sennheiser will be able to retune some of its higher-end equipment to adjust to these changes, but it would be economically impractical to retrofit most other equipment, such as that used by churches and civic organizations. Such equipment will need to be replaced. For all of these reasons, the industry is facing great uncertainty.

The Commission seeks information regarding the development time and life cycles of wireless microphone equipment.<sup>28</sup> Manufacturers cannot fully initiate product development until access to spectrum is more certain, which will not occur until after this proceeding as well as the concurrent Part 15 proceeding.<sup>29</sup> Product development for new frequency bands will require a minimum of three years, but more typically five years, after spectrum is identified and the technical specifications are established.

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<sup>28</sup> NPRM at ¶¶ 42 and 43.

<sup>29</sup> *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 60 MHz Duplex Gap; In the Matter of Promoting Spectrum Access for Wireless Microphone Operations; Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Notice of Proposed Rulemaking, Docket Nos. 14-165 and 12-268 (rel. Sept. 30, 2014) ("Part 15 NPRM").



Regarding life-cycles, wireless microphones are not like consumer products such as cell phones or computers having short life cycles. Many wireless microphones systems are in use for twenty years or more. Whether profession or amateur, owners view this equipment as an investment. Just one example is the non-profit 5<sup>th</sup> Avenue Theater in Seattle, which installed a system in 1992. Although it was still fully functional, the theater replaced it in 2009 to comply with the Commission's mandate to vacate 700 MHz. Now, the theater again must replace its system, due to the TV band repacking, and it estimates that it must conduct a fund raising campaign to generate \$450,000 to cover this cost.

Finally, international harmonization, in both spectrum and technological rules is important to obtain economics of scale, which translates to efficiencies in costs to the consumer.

## **2. Part 74 LPAS Rules Should be Updated to Expand Use.**

The Commission seeks comment on how to accommodate licensed wireless microphones operating in the VHF and UHF spectrum after the TV band repacking. First, the Commission asks about current use of the VHF channels and whether wireless microphones can make better use of those, such as by increasing the power limit to align with what is allowed for operations on UHF channels.<sup>30</sup> Sennheiser agrees that increasing the allowable power on VHF channels would promote greater use by wireless microphones. There is much more noise and out-of-band emissions on these frequencies today than when the rules for wireless microphone operations were first established decades ago. Allowing higher transmitter power of up to 250 mW (*i.e.* harmonized with the UHF rules) will increase the carrier-to-noise ratio and help address these interference issues. However, Sennheiser does not view VHF spectrum as a substitute for "clean" UHF spectrum needed for hyper-critical wireless microphone use.

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<sup>30</sup> NRPM at ¶ 77.

The Commission seeks information regarding whether LPAS licensees may operate co-channel with television, including within the DTV contour, when the television signal is below a certain threshold.<sup>31</sup> Sennheiser has previously made such a proposal, specifically suggesting that wireless microphones be allowed to operate in locations where the co-channel television signal measures below -80 dBm over 200 kHz, and supports a change in the Commission's rules to allow this. Compared to the current geographic approach, this threshold approach would be more useful for both indoor and outdoor operations.

The Commission additionally suggests that the Part 74 rules be revised to require that LPAS devices meet ETSI emission standards.<sup>32</sup> As noted above, Sennheiser devices meet these standards and Sennheiser supports adoption of the ETSI masks.

The Commission asks whether all entities eligible for licenses under the Part 74 LPAS regime be allowed to operate in the duplex gap.<sup>33</sup> Licensed operators need access to as much UHF as possible, considering the amount of 700 MHz spectrum lost and the forthcoming changes due to the incentive auction. Access to spectrum in the duplex gap should be available to all Part 74 eligible licensees.<sup>34</sup> Doing so will not create interference problems for broadcasters and cable operators because they have shared other channels with the licensed as well as unlicensed wireless microphone users for years, without any problems.

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<sup>31</sup> NPRM at ¶¶ 80-84.

<sup>32</sup> NRPM at ¶¶ 87-92.

<sup>33</sup> NPRM at ¶ 95.

<sup>34</sup> Sennheiser similarly proposes below that all Part 74 eligible licensees be able to use the expanded 944-952 MHz band.

**3. The Transition from 600 MHz Will be Difficult and Must be Carefully Managed.**

As noted above, all of the transition issues are creating havoc for the wireless microphone industry. The transition from 600 MHz is particularly difficult because many owners only recently invested in new equipment in order to transition off 700 MHz frequencies.

The Commission seeks comment on how to provide consumer education with regard to the transition.<sup>35</sup> During the 700 MHz transition, Sennheiser conducted a comprehensive education campaign: buying full page ads in all the industry's major publications; launching an educational seminar national tour; developing educational web site pages; and making a series of direct mailings to dealers and end users. Sennheiser already has done much of the same with regard to the upcoming incentive auction. When the possibility that the 600 MHz band would be repurposed became clear, Sennheiser began recommending that customers purchase models that operate in ranges other than 600 MHz. Since that time, this announcement has remained posted on Sennheiser's U.S. website, [www.sennheiserusa.com/spectrum](http://www.sennheiserusa.com/spectrum), along with a comprehensive summary of incentive auction issues relevant to wireless microphone users. Also, Sennheiser has again conducted educational seminars as well as participated in trade show and industry group panels and workshops discussing the changes to the regulatory environment.

The Commission can bolster the overall educational campaign by posting more information on the FCC website targeted to wireless microphone users, information that should easily be found through a search of "wireless mic," "wireless microphone," or other relevant keywords. The information provided should consist of consumer summaries, rather than documents such as the NPRMs. Sennheiser offers the Commission use of any material that it has created for use already.

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<sup>35</sup> NPRM at ¶ 100.



The Commission has proposed cut off dates for certification, manufacturing and marketing of wireless microphones used in the repurposed spectrum.<sup>36</sup> Sennheiser believes that it can meet these timeframes and will support them, but requests that the Commission move quickly to authorize and finalize rules for alternative spectrum bands to allow manufactures to transition as quickly and smoothly as possible.

**D. Operations on Alternative Bands Are Viable but No Substitute for UHF Spectrum.**

As previously stated, Sennheiser supports moving certain operations out of UHF. Hyper-critical applications still require access to reserved UHF spectrum, as well as priority access to shared white spaces spectrum. The Commission has proposed the use of alternative spectrum to meet the needs of the wireless microphone community. Sennheiser appreciates the Commission's efforts and proposes that the Commission consider alternative spectrum based on the three categories of wireless microphone users (Class A, Class B, and Class C) outlined above.

The Commission seeks information regarding the effects of propagation in different frequency bands and the bandwidth needs of wireless audio equipment.<sup>37</sup> In terms of frequency, UHF is ideal for professional performance links, which require very good penetration through building materials and people. For example, during Broadway performances and national tours, signals must penetrate stage sets and the bodies of other performers. The higher the frequency, the more people and building materials will attenuate signals. Use of higher power could overcome propagation problems, but the trade-off is that higher power requires more battery power, which means larger and heavier batteries. Because many professional performers wear

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<sup>36</sup> NPRM at ¶¶ 114-118.

<sup>37</sup> NPRM at ¶ 40, ¶ 150.



devices, devices for many professional uses must be kept light and so cannot use large batteries. Higher power also can aggravate RF noise and intermodulation issues, inhibiting spectral efficiency. In terms of bandwidth, performance links and non-performance links (“backstage,” intercom, cueing, and interruptible fold back) have different requirements. Performance links require high fidelity and low latency, which would be difficult to obtain without availability of the current allowable 200 kHz bandwidth. Non-performance or speech quality links require less, around 25 kHz bandwidth.

Given these criteria, Sennheiser proposes the following:

*26.100-26.480 MHz, 161.625 MHz-161.775 MHz, 450-451 MHz, and 455-456 MHz:* The Commission seeks comment on the current use of these frequencies by wireless microphones, and whether greater use can be made of the spectrum by, for example, technological advances.<sup>38</sup> Presently, these frequencies are rarely used by wireless microphones. The 26 MHz band would be appropriate for base stations due to the need for large antennas and the size of any required filtering components. 161.625-161.775 MHz is on the lower range of functionality for a worn or held wireless microphone device, but the narrow 150 KHz bandwidth would barely accommodate a single medium fidelity link, thus limiting its use to low fidelity links.

Sennheiser believes greater use can be made of the 450-451 and 455-456 MHz frequencies. However, at one megahertz bandwidth, these would provide capacity for a few microphones total, which will not serve to greatly increase spectrum availability.

*88-108 MHz FM Band:* Sennheiser views this band as exceedingly limited in use because antenna length requirements are very cumbersome for worn or held performance devices.

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<sup>38</sup> NPRM at ¶ 122.